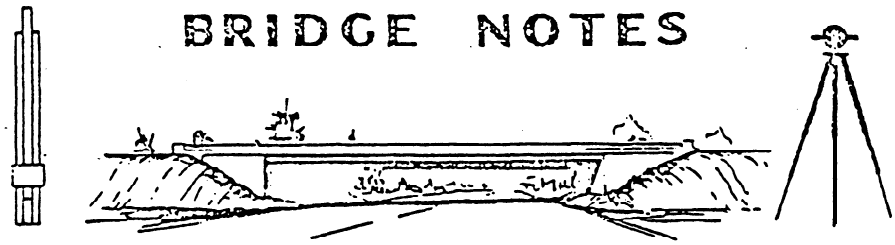
APPENDIX 3

BRIDGE DEPARTMENT

BRIDGE NOTES



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CARELESSLY PLACED RE-BAR CAUSES STRENGTH LOSS

The following study points out the need to accurately place and position the deck steel as called for on the plans. Changes in clearance of the top reinforcing steel in transverse reinforced slabs affects the moment and shear capacity of the slab in the area of negative moment. Figures A and B show a standard slab taken from the "Bridge Planning and Design Manual". Table A shows the effects of varying top steel clearances.

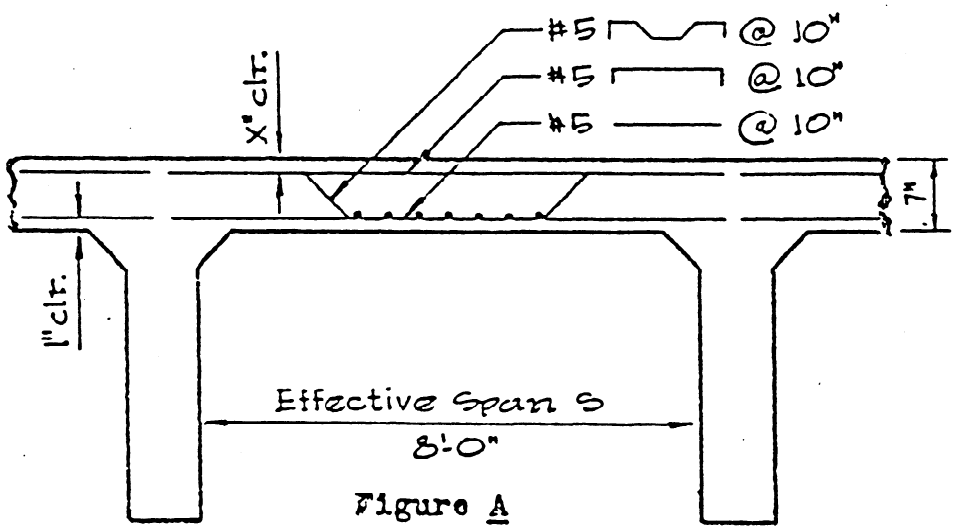


Figure A

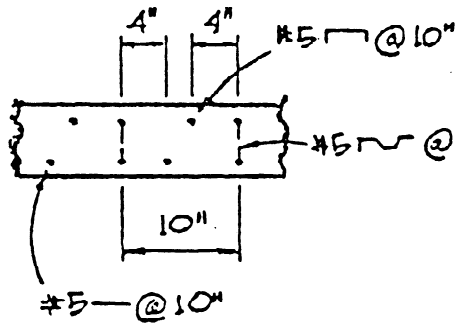


Figure B

4000 psi concrete , Grade 60 rebar

CLEARANCE	D eff	As /ft	Rho	.75 Rho bal	% Mu Cap	% Vu Cap
2	5.75	0.744	0.0107826	0.0214	86	100
2.5	5.25	0.744	0.0118095	0.0214	78	91
3	4.75	0.744	0.0130526	0.0214	70	83
3.5	4.25	0.744	0.0145882	0.0214	61	74
4	3.75	0.744	0.0165333	0.0214	53	65
4.5	3.25	0.744	0.0190769	0.0214	45	57
5	2.75	0.744	0.0225455	0.0214	*	*

Note when the clearance exceeds 4 .5 in. requirements for a ductile section are not met.

MATERIAL SPECIFICATIONS FOR REINFORCING BARS (Cont.)

IDENTIFICATION MARKS* - ASTM STANDARD BARS

The ASTM specifications for billet-steel, rail-steel, axle-steel and low-alloy reinforcing bars (A 615, A 616, A 617 and A 706, respectively) require identification marks to be rolled into the surface of one side of the bar to denote the producer's mill designation, bar size, type of steel, and minimum yield designation. Grade 60 bars show these marks in the following order.

1st - Producing Mill (usually a letter)

2nd - Bar Size Number (#3 through #18)

3rd -Type of Steel: S for Billet meeting supplementary requirement (S 1) of (A 615)

N for Billet (A 615)

R for Rail (A 616) meeting bend test requirements of ASTM A 617, Grade 60 [per ACI 318-83]

for Rail (A 616)

A for Axle (A 617)

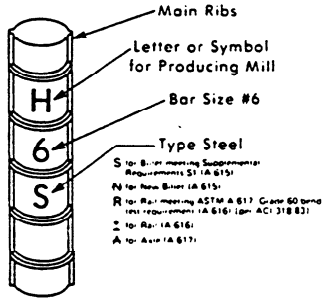
W for Low-Alloy (A 706)

4th - Minimum Yield Designation

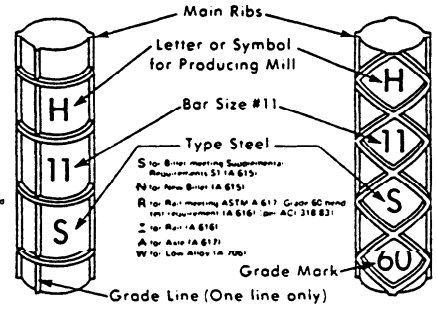
Minimum yield designation is used for Grade 60 bars only and may be either-one single longitudinal line (grade line) or the number 60 (grade mark).

A grade line is smaller and is located between the two main ribs which are on opposite sides of all bars made in the United States. A grade line must be continued through at least 5 deformation spaces, and it may be placed on the side of the bar opposite the bar marks. A grade mark is the 4th mark on the bar.

Grade 40 and 50 bars are required to have only the first three identification marks (no minimum yield. designation).



GRADE 40 AND 50



GRADE 60 AND A 706

VARIATIONS: Bar identification marks may also be oriented to read horizontally (at 90° to those illustrated above).
Grade mark numbers may be placed within separate consecutive deformation spaces to read vertically or horizontally.

ACI BUILDING CODE - REQUIREMENTS FOR REINFORCING BARS

The current ACI Building Code requires billet-steel reinforcing bars to conform to the ASTM A 615 specification including supplementary requirement (S1). As shown in the table on page 1-2 and in the reprint of A 615 in Appendix B, the supplementary requirement (S1) prescribes more-restrictive bend tests for bar sizes #3-#5 in Grades 40 and 60, and for bar sizes #7-#11 in Grade 60; and requires bend tests of #14 and #18 bars. S1 also requires that tensile properties be determined from tests on full-size bars. In other: words, tensile tests of full-size #11, #14, and #18 bars in Grade 60 are required -tensile tests of reduced section specimens for these bar sizes are not permitted. And as indicated above, A 615 reinforcing bars furnished to the supplementary requirement (S1) must be designated for type of steel by the symbol "S" instead of the traditional "N"[1].

Rail-steel reinforcing bars (A 616) must be bend tested, and meet the bend test requirements for axle-steel bars (A 617), Grade 60. As shown above, the Code also requires that the bar markings rolled into the surface of the bars include the letter "R" to designate rail-steel meeting the special bend test requirements.

The ACI Code does not have special requirements for axle-steel (A 617) and low-alloy (A 706) reinforcing bars, nor take any exceptions to the ASTM specifications for these bars.

[1]**See Appendix A for complete identification** marks of concrete reinforcing bars produced by all U.S. manufacturers. The marks, listed **alphabetically by producing mill. include the identification requirements of** ASTM **and the deformation pattern used by each mill.**

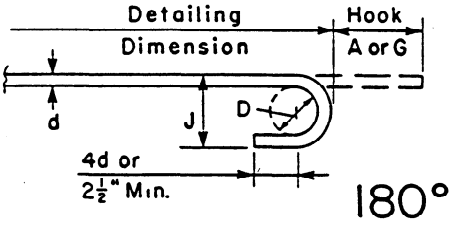
STANDARD HOOKS

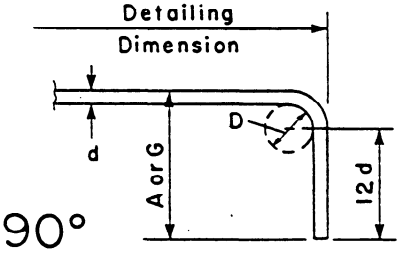
All specific sizes recommended by CRSI below meet minimum requirements of ACI 318-83

RECOMMENDED END HOOKS
All Grades

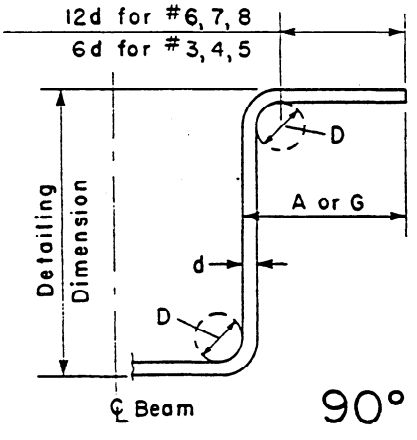
D=Finished bend diameter

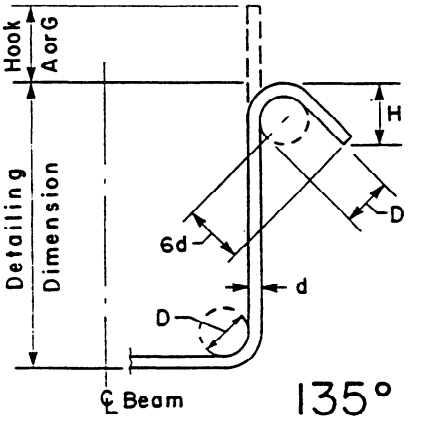
Bar Size	180° HOOKS			90° HOOKS
	D	A or G	J	A or G
# 3	2¼	5	3	6
# 4	3	6	4	8
# 5	3¾	7	5	10
# 6	4½	8	6	1-0
# 7	5¼	10	7	1-2
# 8	6	11	8	1-4
# 9	9½	1-3	11¾	1-7
#10	10¾	1-5	1-1¼	1-10
#11	12	1-7	1-2¾	2-0
#14	18¼	2-3	1-9¾	2-7
#18	24	3-0	2-4½	3-5



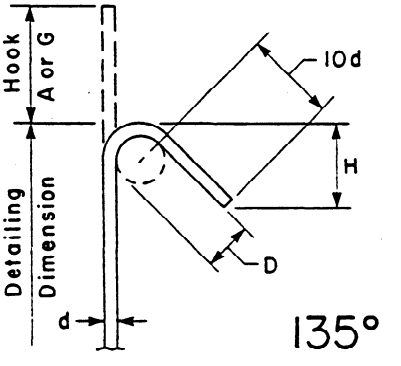


STIRRUP AND TIE HOOKS





135° SEISMIC STIRRUP/TIE HOOKS



STIRRUPS
(TIES SIMILAR)

STIRRUP AND TIE HOOK DIMENSIONS
Grades 40-50-60 ksi

Bar Size	D (in.)	90° Hook	135° Hook	
		Hook A or G	Hook A or G	H Approx.
#3	1½	4	4	2½
#4	2	4½	4½	3
#5	2½	6	5½	3¾
#6	4½	1-0	7¾	4½
#7	5¼	1-2	9	5¼
#8	6	1-4	10¼	6

135° SEISMIC STIRRUP/TIE
HOOK DIMENSIONS
Grades 40-50-60 ksi

Bar Size	D (in.)	135° Hook	
		Hook A or G	H Approx.
#3	1½	5	3½
#4	2	6½	4½
#5	2½	8	5½
#6	4½	10¾	6½
#7	5¼	1-0½	7¾
#8	6	1-2¼	9

NOTES:
1. 180° hook J dimension (sizes #10, #11, #14 and #18), and A or G dimension (#14 and #18) have been revised to reflect recent test research using ASTM/ACI bend test criteria as a minimum.
2. Tables for Stirrup and Tie Hook dimensions have been expanded to include sizes #6, #7, and #8 to reflect current design practices.

CHAPTER 8

RECOMMENDED INDUSTRY PRACTICE - FIELD ERECTION

PLACING REINFORCING BARS*

These recommendations for placing reinforcing bars are based upon the ACI Building Code.

1. GENERAL

Reinforcing bars should be accurately placed in the positions shown on design drawings and adequately tied and supported before concrete is placed, and secured against displacement within the tolerances recommended in Section 7.

Welding of crossing bars (tack welding) should not be permitted for assembly of reinforcement unless authorized by the Engineer.

2. SURFACE CONDITION OF REINFORCEMENT

At the time of concrete placement, all reinforcing bars should be free of mud, oil, or other deleterious materials. Reinforcing bars with rust, mill scale, or a combination of both should be considered as satisfactory, provided the minimum dimensions, weight, and height of deformations of a hand-wire-brushed test specimen are not less than the applicable ASTM specification requirements.

3. BENDING

Reinforcing bars should not be bent or straightened in a manner that will injure the material. Bars with kinks or improper bends should not be used. No bars partially embedded in concrete should be field bent, except as shown on the design drawings or permitted by the Engineer.

4. SPACING OF REINFORCEMENT

The clear distance between parallel reinforcing bars in a layer should not be less than the nominal diameter of the bars, nor 1 in. Clear distance should also not be less than one and one-third times the nominal maximum size of the coarse aggregate, except if in the judgement of the Engineer, workability and methods of consolidation are such that concrete. can be placed without honeycomb or voids.

Where parallel reinforcement is placed in two or more layers, the bars in the upper layers should be placed directly above those in the bottom layer with the clear distance between layers not less than 1 in.

-Groups of parallel reinforcing bars bundled in contact, assumed to act as a unit, not more than four in any one bundle may be used only when stirrups or ties enclose the bundle. Bars larger than #11 should not be bundled in beams or girders. Individual bars in a bundle cut off within the span of flexural members should terminate at different points with at least 40 bar diameters stagger. Where spacing limitations and minimum clear cover are based on bar size, a unit of bundled bars should be treated as a single bar of a diameter derived from the equivalent total area.

In walls and slabs other than concrete joist construction, the principal reinforcement should not be spaced farther apart than three times the wall or slab thickness, nor more than 18 in.

In spirally reinforced and tied columns, the clear distance between longitudinal bars should not be less than one and one-half times the nominal bar diameter, nor 1 1/2 in.

The clear distance limitation between bars should also apply to the clear distance between a contact lap splice and adjacent splices or bars.

5. SPLICES IN REINFORCEMENT**

(a) GENERAL. Splicing of reinforcing bars should be either by lapping, welding, or by mechanical connections.

Splices of reinforcing bars should be made only as required or permitted on the design drawings or in the specifications, or as authorized by the Engineer. All welding should conform to the current edition of "Structural Welding Code - Reinforcing Steel" (AWS D1.4).

(b) LAP SPLICES. Lap splices of #14 and #18 bars should not be used, except in compression only to #11 and smaller bars.

Lap splices of bundled bars should be based on the lap splice length recommended for individual bars of the same size as the bars spliced, and such individual splices within the bundle should not overlap each other. The length of lap should be increased 20 percent for a 3-bar bundle and 33 percent for a 4-bar bundle.

Bar laps placed in contact should be securely wired together in such a manner as to maintain the alignment of the bars and to provide minimum clearances.

Bars spliced by noncontact lap splices in flexural members should not be spaced transversely farther apart than one-fifth the required length of lap nor 6 in.

(c) WELDED SPLICES. A full welded splice is one in which the bars are butted and welded to develop in tension at least 125 percent of the specified yield strength of the bar.

(d) MECHANICAL CONNECTIONS. Mechanical splice devices should be installed in accordance with the manufacturers' recommendations.

A full mechanical connection is one in which the bars are connected to develop in tension or compression at least 125 percent of the specified yield strength of the bar.

6. EMBEDMENT AND EXTENSIONS

(a) Bottom reinforcing bars in beams should extend at least 6 in. into the support. Bottom bars in slabs or joists should extend into the support to the limits of the specified cover or 6 in., whichever is less.

(b) Generally, in one-way continuous construction, unless otherwise called for on the drawings, the top rein-

*For more complete recommendations on *bar* placement, *see* Placing *Reinforcing Bars* available from the Concrete Reinforcing Steel Institute. -
***See Reinforcement Anchorages and Splices* by the Concrete Reinforcing Steel Institute.

forcing bars should extend into adjacent spans to a point three-tenths (0.30) of the greater clear span length beyond the far face of the support. Generally at discontinuous ends, top bars should extend into-the span at least one quarter (0.25) of the clear span length beyond the face of the support and extend into the support to the specified cover at the outer faces of the members into which they frame.

7. TOLERANCES IN PLACEMENT

Unless otherwise specified, reinforcing bars should be placed within the following tolerances:

(a) Tolerance for depth, and minimum clear concrete cover in flexural members, walls and columns should be as follows:

	Tolerance on d	Tolerance on minimum concrete cover
$d \leq 8$ in.	± 3/8 in.	−3/8 in.
$d > 8$ in.	± 1/2 in.	−1/2 in.

Except that the tolerance for the clear distance to formed soffits should be - 1/4 in., and the tolerance for cover should not exceed minus one-third of the minimum cover required on the design drawings or in the specifications.

Note: "d" is the specified effective depth.

(b) Tolerance for logitudinal location of bends and ends of bars should be ±2 in. except at discontinuous ends of members where the tolerance should be 2 1/2 in.

(c) As long as the total number of bars specified is maintained, a reasonable tolerance in spacing individual bars is ± 2 in., except where openings, inserts, embedded items, etc., might require some additional shifting of bars.

(d) Tolerance for length of laps in lap splices should be ± 1 in.

(e) Tolerance for embedded length should be 2 1 in. for #3 through #11 bars, and -2 in. for #14 and #18 bars.

8. SUPPORTS

The use of bar supports should follow the industry practices presented in Chapter 3 of this Manual, except as noted on the contract drawings.

Placing bars on layers of fresh concrete as the work progresses and adjusting bars during the placing of concrete should not be permitted.

The required positioning of supports in post-tensioned construction to provide proper tendon profile should be in accordance with the placing drawings provided by the post-tensioning contractor and approved by the Engineer. The sequence of placing reinforcing bars in conjunction with tendons and/or ducts should be the responsibility of the Engineer.

9. CONCRETE PROTECTION FOR REINFORCEMENT

The following minimum concrete cover should be provided for reinforcing bars. For bundled bars, the minimum cover should be equal to the equivalent diameter of the bundle but need not be greater than 2 in.; except for concrete cast against and permanently exposed to earth, the minimum cover should be 3 in.

(a) CAST-IN-PLACE CONCRETE (nonprestressed)

	Minimum cover, in.
Concrete cast against and permanently exposed to earth	3
Concrete exposed to earth or weather:	
#6 through #18 bars	2
#5 bars, W31 or 031 wire, and smaller	1½
Concrete not exposed to weather or in contact with the ground:,	
Slabs, walls, joists:	
#14 and #18 bars	11/2
#11 bars and smaller	3/4
Beams, girders, columns:	
Primary reinforcement, ties, stirrups or spirals	1 1/2
Shells and folded plate members:	
#6 bars and larger	3/4
#5 bars, W31 or D31 wire, and smaller	1/2

(b) PRECAST CONCRETE (manufactured under plant control conditions)

	Minimum cover, in.
Concrete exposed to earth or weather;	
Wall panels:	
#14 and #18 bars	1 1/2
#11 bars and smaller	3/4
Other members:	
#14 and #18 bars	2
#6 through #11 bars	1 1/2
#5 bars, W31 or 031 wire, and smaller	1 1/4
Not exposed to weather or in contact with the ground:	
Slabs, walls, joists	
#14 and #18 bars	1 1/4
#11 bars and smaller	5/8
Beams, girders, columns:	
Primary reinforcement	d_b but not less than than 5/8 need not exceed 1 1/2
Ties, stirrups, or spirals	3/8
Shells and folded plate members:	
#6 bars and larger	5/8
#5 bars, W31 or 031 wire, and smaller	3/8

(c) In corrosive atmospheres or severe exposure conditions, the amount of concrete protection should be suitably increased, and the denseness and nonporosity of the protecting concrete should be considered, or other protection should be provided.